SHADING INSTRUMENT SHELTERS.

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[Weather Bureau Office, Topeka, Kans., May 25, 1920.]

The present style of instrument shelter was adopted by the Weather Bureau early in the nineties after a long and careful investigation of the best exposure for thermometers and is generally conceded to be the most practicable shelter in use in obtaining the temperature of the free air. It was assumed that the use of the double top and white paint, combined with the excellent ventilation afforded by the louvered sides, would eliminate from the thermometer readings within, the direct heating effect of the sun's rays on the shelter as well as the loss of heat by radiation from the shelter itself, so that for all practicable purposes it would give the temperature of the free air as accurately if fully exposed to the sun's rays as it would in a shady location, provided in each case it had a free circulation of air about it and there was no interference due to reflected heat from nearby objects.

The question of whether the standard instrument shelter was really efficient in overcoming the effects of insolation and radiation was brought to the attention of Mr. P. C. Day, Chief of the Climatological Division, United States Weather Bureau, during his visit at Topeka in the fall of 1916, and at his suggestion arrangements were made for a series of readings from thermometers in a shelter freely exposed to sunlight and also from thermometers in a nearby shelter that was shaded.

Two instrument shelters of the type in general use at the cooperative stations of the Weather Bureau and two sets of standard maximum and minimum thermometers were located in the summer of 1917 a mile west of the limits of the city of Topeka, in Gage Park, on ground that was gently rolling. One shelter was placed over thick sod, entirely in the open (see fig. 1), and the other 141 feet north under a spreading box elder tree at the rear of the residence of the park superintendent, where it was densely shaded all day during the season that the tree was in leaf—approximately from April 15 to October 15—and thinly shaded by the naked limbs of the tree the remainder of the year, but had an excellent circulation of air about it. (See fig. 2.) The ground between the shelters and for a considerable distance in every direction is almost level.

Mr. E. F. A. Reinisch, park superintendent, kindly consented to record the readings of the two sets of thermometers and reset them each evening, and it is to his faithful and painstaking work that credit should be given for the successful completion of the series of comparative readings.

At the end of 1918 the "shade" shelter was moved to beneath another box elder tree 150 feet west of the "sun" shelter in order to eliminate any possible effect of interference with the circulation of the air on account of the proximity of one or two low buildings. (See fig. 3.) In this new location the wind was as free to blow about the shelter as it usually is under an isolated shade tree, but the shelter itself never felt the direct rays of the sun, except during the winter season—October 15 to April 15—when the leaves were off and the limbs of the tree made only a thin shade. The observations, however, show no noticeable effect of the difference between the two locations. The location of the "sun" shelter was not changed during the series of readings.

Observations were begun in July, 1917, and continued until the end of February, 1920. Only the two complete years, 1918, with the "shade" shelter as shown in figure 1, and 1919, with it as shown in figure 2, are considered in this discussion, as the partial records of 1918 and 1920 throw no new light upon the subject.

Throughout the series there was a consistent tendency for the daily maximum temperatures in the "sun" shelter to range higher and the minima in that shelter to range lower than the corresponding record in the "shade" shelter. Sometimes this difference would be only a fraction of a degree but, as shown by Table 7, there were usually one or more days each month when the difference amounted to 3° or 4° and on rare occasions in summer to 6° or 7°. The differences between the daily maximum temperatures in the two shelters were usually somewhat greater than those of the minimum temperatures, as shown by the values in Tables 2 and 7, so that the heating effect on the "sun" shelter was evidently greater than the nightly interference with radiation by the tree above the "shade" shelter, and these two effects combined to make the mean daily range of temperature in the "sun" shelter from 3.6° to 4.4° greater than that in the "shade" shelter in the summer time, when the tree was in full leaf and from 0.8° to 1.8° F. greater in the winter time when the tree was bare. (See Table 8.)

As shown by Table 1, the mean monthly temperatures in the "sun" shelter regularly ranged from 0.5° to 0.9° F. higher than those in the "shade" shelter in the summer and from 0.3° to 0.9° F. lower in the winter months but, oddly enough, in both years covered by the record the annual means were only 0.1° F. apart. An examination of the monthly mean maximum and mean minimum temperatures as given in Tables 2 and 3 indicates that the excess in temperature in the summer time in the "sun" shelter was due to the fact that the direct rays of the sun during the long days were more effective in raising the temperature inside it than the radiation of the short summer nights was in cooling it. In the winter season the reverse obtained. That is, radiation at night lowered minimum temperatures in the "sun" shelter more than direct sunshine raised maximum temperatures in it compared with similar readings in the "shade" shelter, which accounts for the deficiency in mean monthly temperature in the "sun" shelter in the winter season.

From the foregoing it is evident that daily temperatures observed in a standard instrument shelter freely exposed to the sun's rays are not comparable with those in a shaded shelter, though the difference in the annual mean may be negligible. As the increasing use of free-air temperature data for research purposes demands the elimination of every possible source of error, exposure as well as instrumental, it becomes highly important either that a shelter be evolved that will eliminate the effects of isolation and radiation entirely or that special care be taken to have a uniform exposure for all shelters of the present type.

This series of observations does not, of course, settle the question of which more nearly represented free air temperatures—those in the "sun" shelter or those in the "shade" shelter—but it certainly does demonstrate the importance of giving uniform exposure to all shelters used for getting free air temperatures whether at the 200 fully equipped Weather Bureau stations or the nearly 4,500 cooperative stations. Although a short series of observations at one locality is not a sufficient basis for accurate conclusions, it appears that any *serious* studies of temperature observations will have to take into consideration the effect of the location of the instrument shelters, though possibly for ordinary compilations this may be disregarded.

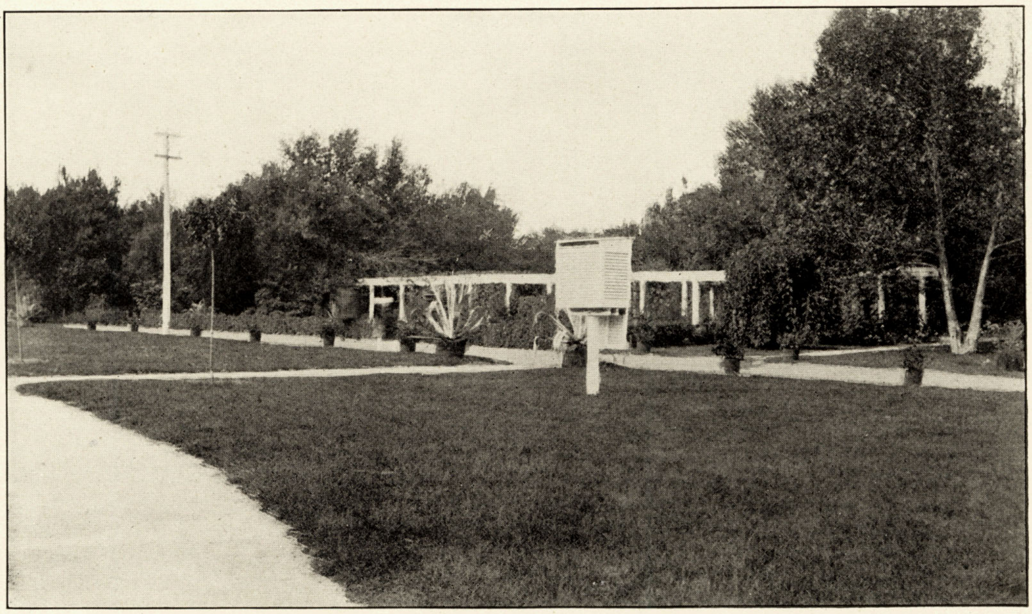

Fig. 1.—Location of "sun" shelter in Gage Park. Camera pointing toward the northwest.

Fig. 2.—First location of "shade" shelter at Gage Park, 141 feet north of "sun" shelter. Camera pointing toward southwest.

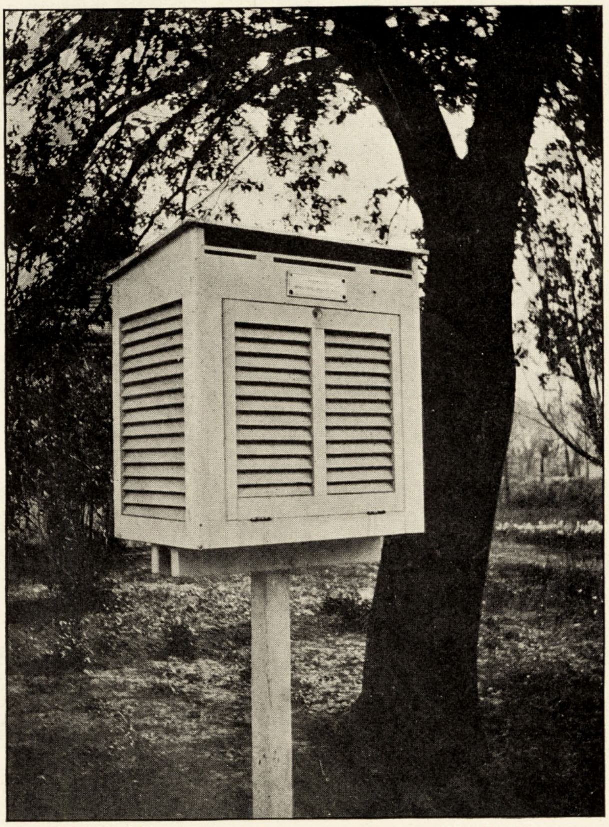

Fig. 3.—Second location of "shade" shelter at Gage Park, 150 feet west of "sun" shelter. Camera pointing toward southwest.

TABLE 1.—*Mean temperatures.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918.													
"Sun" shelter..	17.4	34.6	50.0	50.0	69.6	78.3	77.4	82.7	62.4	60.2	41.1	36.7	55.0
"Shade" shelter..........	17.7	34.8	50.2	50.0	69.2	77.6	76.6	82.2	62.2	59.7	41.4	37.6	54.9
Difference....	−0.3	−0.2	−0.2	0.0	+0.4	+0.7	+0.8	+0.5	+0.2	+0.5	−0.3	−0.9	+0.1
1919.													
"Sun" shelter..	30.7	34.5	44.8	54.4	62.6	74.1	80.6	77.0	71.2	55.1	42.2	25.8	54.4
"Shade" shelter..........	31.2	34.6	44.8	54.0	62.2	73.2	80.0	76.4	71.0	55.2	42.6	26.1	54.3
Difference....	−0.5	−0.1	0.0	+0.4	+0.4	+0.9	+0.6	+0.6	+0.2	−0.1	−0.4	+0.3	+0.1

TABLE 2.—*Mean maximum temperatures.*

	Jan.	Feb	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec	Annual.
1918.													
"Sun" shelter..	29.6	49.5	66.5	62.4	81.5	91.9	90.6	96.8	76.4	72.1	48.5	46.8	67.7
"Shade" shelter..........	29.1	49.0	65.8	61.0	79.9	89.2	87.8	94.1	73.4	69.5	47.8	46.8	66.1
Difference....	+0.5	+0.5	+0.7	+1.4	+1.6	+2.7	2.8	+2.7	+3.0	+2.6	+0.7	0.0	+1.6
1919.													
"Sun" shelter..	43.8	45.5	56.8	65.2	74.1	85.3	94.5	90.7	85.1	67.7	56.5	35.4	66.7
"Shade" shelter..........	43.5	45.2	56.1	64.2	72.2	82.6	91.8	88.0	82.9	66.3	56.1	35.0	65.3
Difference....	+0.3	+0.3	+0.7	+1.0	+1.9	+2.7	+2.7	+2.7	+2.2	+1.4	+0.4	+0.4	+1.4

TABLE 3.—*Mean minimum temperatures.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918.													
"Sun" shelter..	5.3	19.7	33.4	37.6	57.6	64.7	64.1	68.6	48.5	48.4	33.7	26.6	42.4
"Shade" shelter..........	6.3	20.7	34.6	38.2	58.6	66.0	65.4	70.3	50.5	49.9	34.9	28.4	43.6
Difference....	−1.0	−1.0	−1.2	−0.6	−1.0	−1.3	−1.3	−2.3	−2.0	−1.5	−1.2	−1.8	−1.2
1919.													
"Sun" shelter..	17.6	23.5	32.7	43.6	51.1	62.9	66.8	63.4	57.2	42.5	27.9	16.3	42.1
"Shade" shelter..........	18.9	24.0	33.4	43.9	52.2	68.8	68.3	64.7	59.1	44.1	29.2	17.2	43.2
Difference....	−1.3	−0.5	−0.7	−0.3	−1.1	−0.9	−1.5	−1.3	−1.9	−1.6	−1.3	−0.9	−1.1

TABLE 4.—*Maximum temperatures.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept	Oct.	Nov.	Dec.	Annual.
1918.													
"Sun" shelter..	52	78	85	80	92	106	104	109	92	92	72	69	[1] 109
"Shade" shelter..........	52	76	85	80	90	103	100	107	88	87	69	69	[1] 107
Difference....	0	+2	0	0	+2	+3	+4	+2	+4	+5	+3	0	+2
1919.													
"Sun" shelter..	65	62	70	86	86	98	104	104	98	92	70	[a] 68	[2] 104
"Shade" shelter..........	66	61	70	85	84	95	100	101	96	91	69	[a] 67	[3] 101
Difference....	−1	+1	0	+1	+2	+3	+4	+3	+2	+1	+1	+1	+3

[1] Aug. 3. [2] July 31, Aug. 6. [3] Aug. 6.

TABLE 5.—*Minimum temperatures.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918													
"Sun" shelter..	−18	−16	15	20	30	49	52	48	30	32	12	−3	[1] −18
"Shade" shelter	−17	−15	17	22	32	50	55	51	34	34	14	−1	[1] −17
Difference....	1	1	2	2	2	1	3	3	4	2	2	2	−1
1919.													
"Sun" shelter..	−19	0	1	27	38	46	54	50	42	24	5	−15	[2] −19
"Shade" shelter	−18	2	3	28	40	47	56	50	45	25	7	−13	[3] −18
Difference....	1	2	2	1	2	1	2	0	3	1	2	2	−1

[1] Jan. 12. [2] Jan. 2, 3. [3] Jan. 3.

TABLE 6.—*Greatest daily range of temperature.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918.													
"Sun" shelter..	44	52	49	45	40	39	39	45	42	43	35	34	52
"Shade" shelter	41	48	47	44	37	33	30	40	44	35	38	34	48
Difference....	3	4	2	1	3	6	9	5	2	8	3	0	.....
1919.													
"Sun" shelter..	49	43	42	42	37	36	41	42	46	42	42	[a] 43	49
"Shade" shelter	49	42	39	39	34	31	35	36	40	37	40	[a] 41	49
Difference....	0	1	3	3	3	5	6	6	6	5	2	2	.....

TABLE 7.—*Greatest difference between daily readings on any day.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean difference.
1918.													
Maximum temperatures.....	3	4	5	3	4	4	4	6	5	7	3	3	4.2
Minimum temperatures.....	3	3	3	3	3	7	3	4	4	4	3	3	3.6
1919.													
Maximum temperatures.....	3	2	2	3	6	4	4	4	6	4	4	2	3.7
Minimum temperatures.....	3	4	2	2	3	2	3	4	5	3	2	4	3.1

NOTE.—In each instance given in this table the maximum was higher and the minimum lower in the "sun" shelter.

TABLE 8.—*Mean daily range of temperature.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1918.													
"Sun" shelter..	24.3	29.8	33.1	24.8	23.9	27.2	26.5	28.2	27.9	23.7	14.8	20.2	25.3
"Shade" shelter	22.8	28.3	31.2	22.8	21.3	23.2	22.4	23.8	22.9	19.6	12.9	18.4	22.5
Difference....	1.5	1.5	1.9	2.0	2.6	4.0	4.1	4.4	5.0	4.1	1.9	1.8	2.8
1919.													
"Sun" shelter..	26.2	22.0	24.1	21.6	23.0	22.4	27.7	27.3	27.9	25.2	28.6	19.1	24.6
"Shade" shelter	24.6	21.2	22.7	20.3	20.0	18.8	23.5	23.3	23.8	22.2	26.9	17.8	22.1
Difference....	1.6	0.8	1.4	1.3	3.0	3.6	4.2	4.0	4.1	3.0	1.7	1.3	2.5

THE STANDARD ATMOSPHERE.

(Discussion.)

With the advance of aeronautics and the science of artillery, engineers and specialists in these fields have come to require a specific knowledge of the varying states of the atmosphere from the ground to very great elevations. This has led to the introduction of a conventional term commonly known as *the standard atmosphere*, which pretends to specify the normal or average condition. As is well known, the "standard atmosphere" is never found; that is to say, at no time or place do "standard" or average conditions of all of the meteorological elements at all altitudes simultaneously occur. Nevertheless it is proper, and in certain fields (especially those of aviation and ordnance) it is necessary, to adopt so-called "standard" values, and it is desirable to have these represent as closely as possible true mean values in order that corrections due to departures from these means may be comparatively small in most cases. It would be advantageous, so far as accuracy is concerned, to use at least three sets of "standard" conditions—one for summer, one for winter, and a third for spring and autumn; but this would complicate the matter, so far as practical use is concerned, and the usual custom is, therefore, to adopt one set of values only and to use this set in com-